Heathkit of the Month:
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HEATHKIT

Heathkit IG-4505 Oscilloscope Calibrator

Introduction:

Heathkit has manufactured numerous oscilloscope kits over the years. Early scopes have variable vertical amplifiers (usually AC coupled) and sweep generators. Measuring actual voltage or frequency (period of a wave) requires some form of external signal to compare to the signal being measured. Newer oscilloscopes have calibrated vertical and horizontal amplifiers, and time bases. The amplifiers (DC coupled) have a switched gain control marked in Volts-per-Division. The time-base is also switch selected, marked in Seconds-per-Division. A typical Heathkit oscilloscope of the 1980's, such as the IO-4235, has a voltage range of 2mV/Div. to 10 V/Div. in a 1-2-5 sequence, and a time-base range of 0.05 µSec. to 0.20 Sec. The vertical input is often used with a scope probe that has a 10X attenuation. And the time-base has a X5 switch.

These newer scopes allow you to easily get a good approximation of the frequency and voltage when looking at a waveform. However, to initially calibrate such a scope requires a calibrator, such as the Heathkit IG-4505 (Figure 1), with accurate voltage and frequency outputs. Newer scopes generally have a higher frequency vertical amplifier response (35 MHz in the case of the IO-4235). In order to get good response, the front end attenuators must also be calibrated. This requires a square wave with a very fast and clean rise time.

Figure 1: Heathkit IG-4505 Deluxe Oscilloscope Calibrator

Heathkit Scope Calibrators:

Over the years, Heathkit produced six models of oscilloscope calibrators that I am aware of. In 1952 Heathkit introduced the VC-1 voltage calibrator ($9.50), followed a year later by the VC-2 ($11.50) (Figure 2). In 1956 the VC-2 was replaced by the VC-3 ($12.50) that was sold through 1962. These three units output a calibrated AC voltage. The VC-1 and VC-2 have peak-to-peak 60 Hz. outputs of 0.1 V, 1 V, 10 V and 100 V. A variable potenti-

Figure 2: VC-2 Scope Voltage Calibrator

Figure 3: Heathkit IOA-4510-1 Low Cost Scope Calibrator

ometer marked 0 - 10 allows you to scale the voltage in each range. The VC-3 is a bit more accurate with 1 KHz fixed peak-to-peak output voltages from 0.03 V to 100 V in a 1-3 sequence. These three calibrators also have a **SIGNAL** input that can be switched to the output so you don't have to change leads to switch between the signal and the the calibrator. The three newer units are for actually calibrating the fixed gain and time-base of an advanced oscilloscope.

The IOA-4510-1 Low-Cost Calibrator:

The IOA-4510-1 calibrator (Figure 3) was originally designed for the IO-4510 10 MHz scope. Produced from 1974 through 1981, it sold for $14.95 in 1977 and for $17.95 in 1981. This calibrator is just a circuit board with square-wave outputs from 1 KHz to 1 MHz The 1 KHz is adjustable from 0 to 4.7 V peak-to-peak. Power is derived from the oscilloscope under test. Signal selection is through a shielded clip-lead provided with the kit.

The Heathkit IG-4244 Precision Calibrator:

The IG-4244 is the last of the calibrators manufactured by Heathkit. It was "new" in the Christmas 1983 catalog, (see Figure 4) and sold for $149.95. An assembled and tested model, the SG-4244, was available for $249.95. The kit continued to be available into 1992 selling for $199.95. The calibrator is able to calibrate scopes above 100 MHz. It has two crystal oscillators and covers a voltage range of 1 mV to 100 V in 1-2-5 sequence at an accuracy of 1% and a rise time of <5 uSec.. The time-base range is 10 nSec. to 0.5 Sec in a 1-2-5 sequence with an accuracy of 0.015% and a rise time of <1nSec. when properly terminated. There is also a sine-wave output for calibrating triggering circuits. This is a complex calibrator, as indicated by its price. Perhaps some day the IG-4244 will be featured in this column?

The Heathkit IG-4505 Deluxe Calibrator:

The IG4505 was in production from late 1975 until 1990. Until the IG-4244 was introduced it was named the "Deluxe" scope calibrator. Afterwards the name changed to the "Economical" scope calibrator. The IG-4505 originally sold for $44.95. In the fall of 1989 the price had risen to $69.95.

On September 19th, 1979 I walked into the local Heathkit store, located on Ball Road in Anaheim, and purchased an IG-4505 to calibrate the new IO-4235 delayed sweep, dual channel, 35 MHz oscilloscope I had just completed. Prices at Heathkit's retail outlets were commonly higher than the factory prices, so the bill came to $49.95 (plus $3.00 for the then 6% CA tax).

The IG-4505 was introduced shortly before the IO-4235, likely for calibrating it and other new scopes Heathkit had on the board.

Heathkit IG–4505 Specifications:

The IG-4505 has two outputs, a voltage output and a time-base output. The peak square wave voltage output has six decade steps from 1 mV to 100 V. A seventh position grounds the output lead. The voltage accuracy is 2% with a rise time of 2 µSec. The voltage output frequency can be selected from 2 Hz up to 10 KHz in a 1-2-5 sequence. DC output can also be selected on the voltage switch. The voltage output is available via a pair of red-black binding posts on the front panel.

The Time-base output is a nominal 200 mV peak square wave. The frequency range is 1 uSec to 0.5 Sec in a 1-2-5 progression with an accuracy of 0.01% and a rise time of <4 nSec. The time-base output is a coax cable a few feet long terminated with a BNC connector and a built-in 51Ω terminating resistor.

Overall, the IG-4505 weighs 2-1/4 lbs. and measures 2-3/4" H x 9-1/8' W x 4-1/4' D. Power requirements are 120 VAC or 240 VAC at 13 watts.

The front panel of the Heathkit IG-4505 has two rows of controls and outputs. These are shown in table one. The rear panel of the IG-4505 sports only the three-wire power cord and the Blue-White ID label.

Kit Assembly:

Most of the components mount on a single circuit board which is "stuffed" first (components soldered on). The board contains 5 transistors, 10 diodes and seven integrated circuits plus numerous resistors and capacitors. Two rotary switches mount to the board, but the connections are by wire, not PC terminals. Also on the board is the voltage calibration potentiometer. A three position slide switch is mounted similarly.

Front Panel Top Row (L to R)

Switch - 2 pos. Slide: **POWER**
OFF - ON

Lamp - Pilot (Neon): **POWER**

Switch - 7 pos. Rotary: **VOLTS OUT**
(**100V, 10V, 1V, 100mV, 10mV, 1mV, GND**)

Switch - 7 pos. Rotary: **TIME OUT**
(**DC, .1S, 10mS, 1mS, .1mS, 10µs, 1µs**)

Switch - 3 pos. Slide: **TIME OUT**
(**X1, X2, X5**)

Front Panel Bottom Row (L to R)

Binding Post - dual (red, blk): **VOLTS OUT**
Cable - 30", BNC male, 50Ω terminated

RG-58 coaxial. **TIME OUT**

Table I: IG-4505 Front Panel Controls, Etc.

Most of the remaining components, not directly mounted to the chassis, mount on two large terminal strips. Cleverly, Heathkit has you mount these terminal strips to the outside back of the chassis temporarily while you wire them up due to limited space inside the chassis. These terminal strips hold the power supply filter capacitors and the voltage regulator components.

Next the chassis components are mounted. The OFF-ON switch, two binding posts, a rubber grommet for the time-base output cable, some solder lugs, and the power transformer with another terminal strip mounted on one of its fasteners. This terminal strip, with part of one of the others, is used to wire the unit for 120 or 240 VAC.

Chassis wiring is then started; the power cord is prepared and mounted using a strain relief. The terminal strips, prepared earlier, are mounted inside the chassis and final chassis wiring is conducted. The circuit board is then installed and the three switches prewired to the circuit board are fastened to the front panel. Finally the time-base cable is prepared and installed as are the knob.

A tradition, born in the late sixties, is then performed: The Heathkit "Blue and White" identification label is attached to the rear of the chassis. This label shows the model and serial number of the equipment.

After checkout and calibration, final assembly consists only of installing the chassis cover.

Testing and Calibration:
Testing involves powering up the unit, checking for smoke and looking at the waveforms on your oscilloscope. Should you experience a problem, the manual comes with an extensive section, including three pages of flowcharts, covering troubleshooting.

Calibration is straight forward with only one adjustment. The time base accuracy is set by the crystal. The voltage adjustment can be done either with an accurate DVM or using a built-in reference and an analog voltmeter.

Operation:
Using the IG-4505 oscilloscope calibrator is simple. Getting to the adjustments in your scope might not be as easy. Heathkit scopes usually have good access to their adjustments.

Time-base calibration is done by connecting the time base output cable to [one of] your scope's vertical channel input[s]. The scope's time-base range to be calibrated is then set and a time-base signal from the calibrator is selected that gives a square-wave that covers numerous divisions. The scope time-base is then adjusted so the waveform covers the correct number of divisions. For instance, say you are calibrating the 10 mSec/Div. time base. Assuming the scope has ten horizontal divisions select 50 mSec on the calibrator. then adjust the scope's time-base so one

Figure 4: Ad in 1983 Catalog #863 Introducing New IG-4244 Calibrator

full cycle of the square wave displayed is five divisions wide.

Voltage calibrations are done using the voltage output connected to the scope's voltage input to be calibrated with its range set to the desired voltage to be calibrated. The calibrator is then set to a voltage that makes the square wave fill much of the vertical divisions. Then the scope's vertical calibration control is adjusted to it fills the correct number of divisions on the scope.

Another important scope adjustment is the vertical amplifier compensation. In this case use the 1 µSec time-base output and adjust the vertical compensation capacitor(s) for the best square wave without overshoot.

The IG-4505 oscilloscope calibrator can also be used measure the bandwidth of the oscilloscope's amplifiers.

IG-4505 Circuit:
The circuit of the IG-4505 is quite straight forward. There are two power supplies. a regulated five volt supply for most of the ICs and miscellaneous circuits and a zener regulated 110 volt power supply, for the voltage output.

The time-base is a 4 MHz oscillator which is divided to 2 MHz followed by a 7490 IC dividing the 2 mHz by two and by five. The three resulting signals, 2 MHz, 1 MHz and 400KHz are then selected by the **TIME OUT X1 X2 X5** switch and then divided by two again. The resulting 1 µSec., 2 µSec. and 5 µSec. square wave time-base signals are then fed into a string of five divide-by-ten ICs. One of those outputs is then selected by the decade **TIME OUT** switch where it goes to a pair of emitter coupled fast switching transistors driving the fast rise-time **TIME OUT** cable.

The output from the timeout circuit, before the final driver transistors, also goes to the voltage circuit. Here it drives two high voltage transistors connected in series. When the bottom transistor is conducting, driven by the time-base signal, it drops the voltage on the emitter of the upper transistor to cutoff. When the time base signal goes low the lower transistor cuts off causing the upper transistor to conduct. Thus the collector of the lower transistor switches from between about 108 volts and ground. This voltage is fed through a calibration pot to a precision voltage divider where decade voltages between 100 V and 1 mV are tapped off by the VOLTS OUT switch and sent to the front panel VOLTS OUT binding posts.

Conclusion:
This is one of those tools that you don't need often, but when you do it earns its cost. Occasionally it gets used as a signal generator. Other than an out-of tolerance resistor that sometimes caused the crystal oscillator not to start, it has worked well.

73, from AF6C

Remember, if you are getting rid of any old Heathkit Manuals or Catalogs, please pass them along to me for my research.
Thanks - AF6C

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